RadThermIR simulation and measurement of temperature distribution on CUBI

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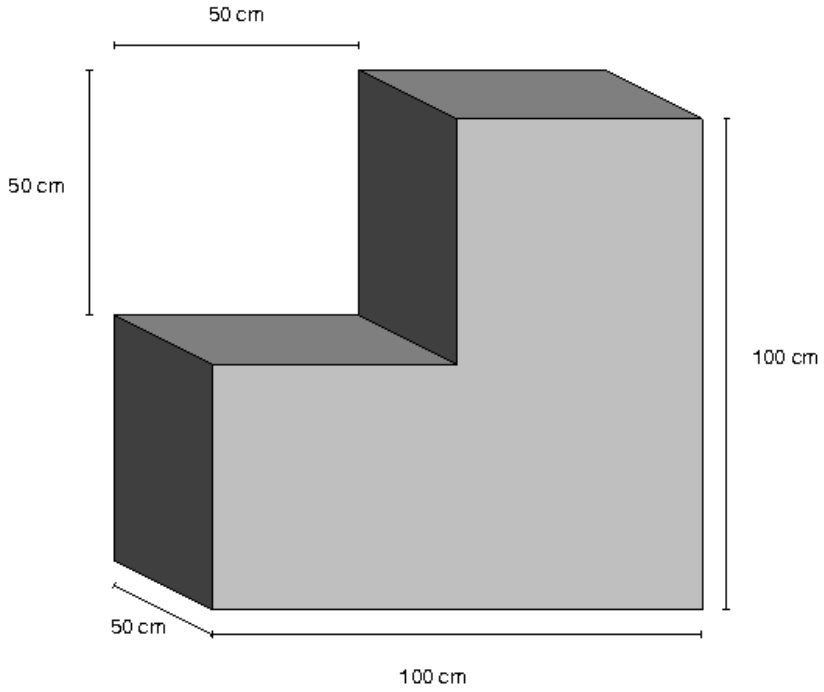
7th RadTherm UGM 2011, Munich

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

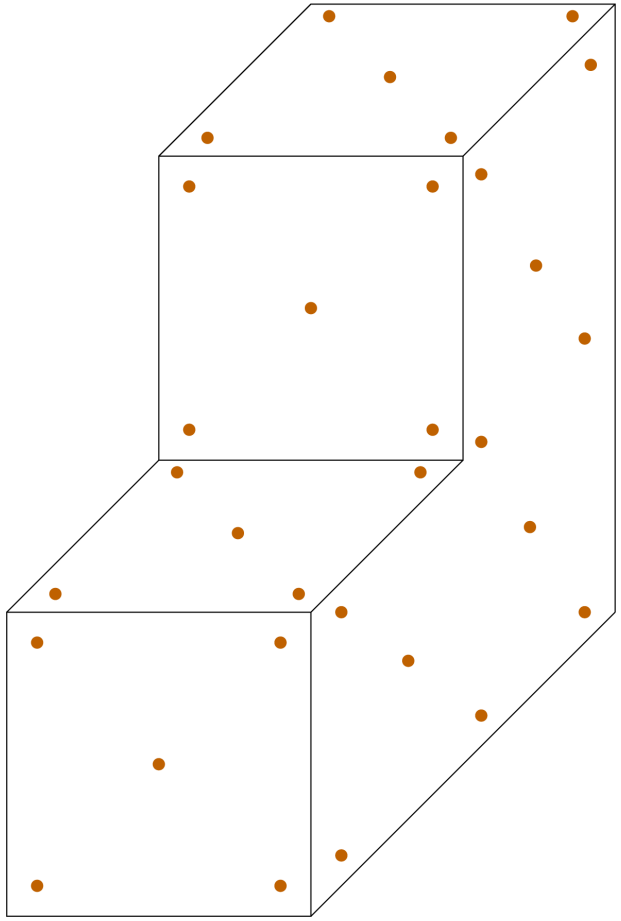
The CUBI

- basic idea:
  - physical test object for IR signature modelling under time-varying weather conditions
  - geometry is simple, but includes shadowing effects
- shape and dimensions are specified, while materials and points of measurement are not



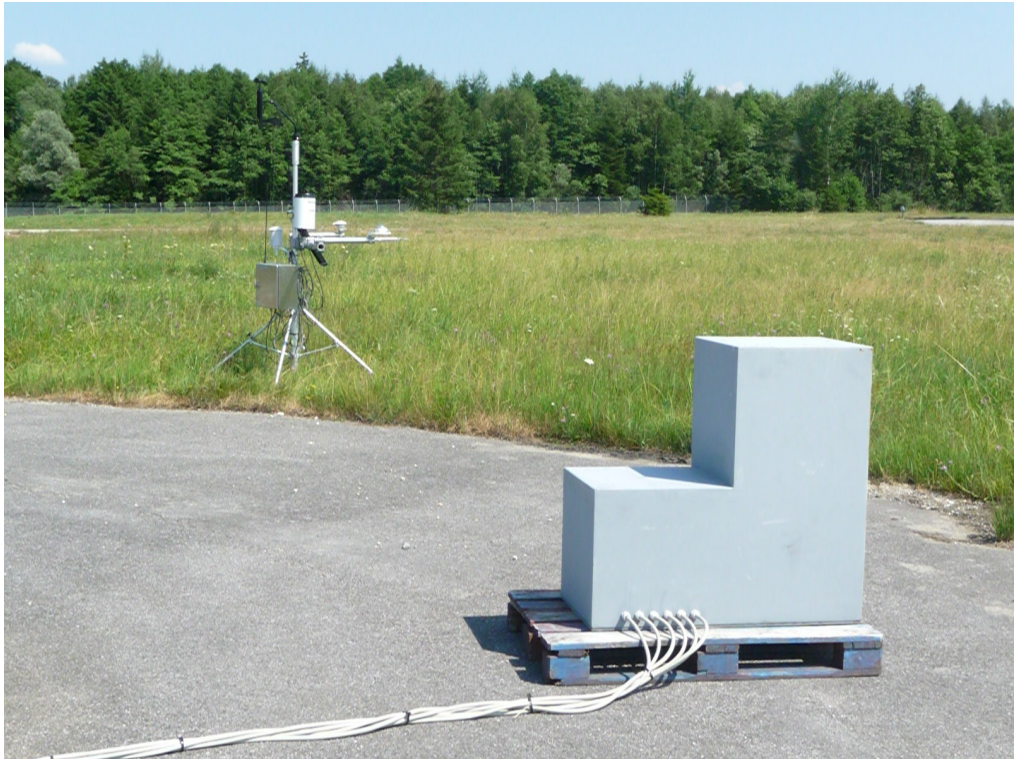
CUBI configuration of DLR

- *material:* 4 mm steel plates
- *insulation:* 60 mm layer of rock wool inside
- distribution of 47 temperature sensors (Pt100), under steel layer, connected to data logger
- stands on wooden pallet in order to be decoupled from the ground



Location

- CUBI is placed at the area of DLR Satellite Ground Station near Weilheim, Germany



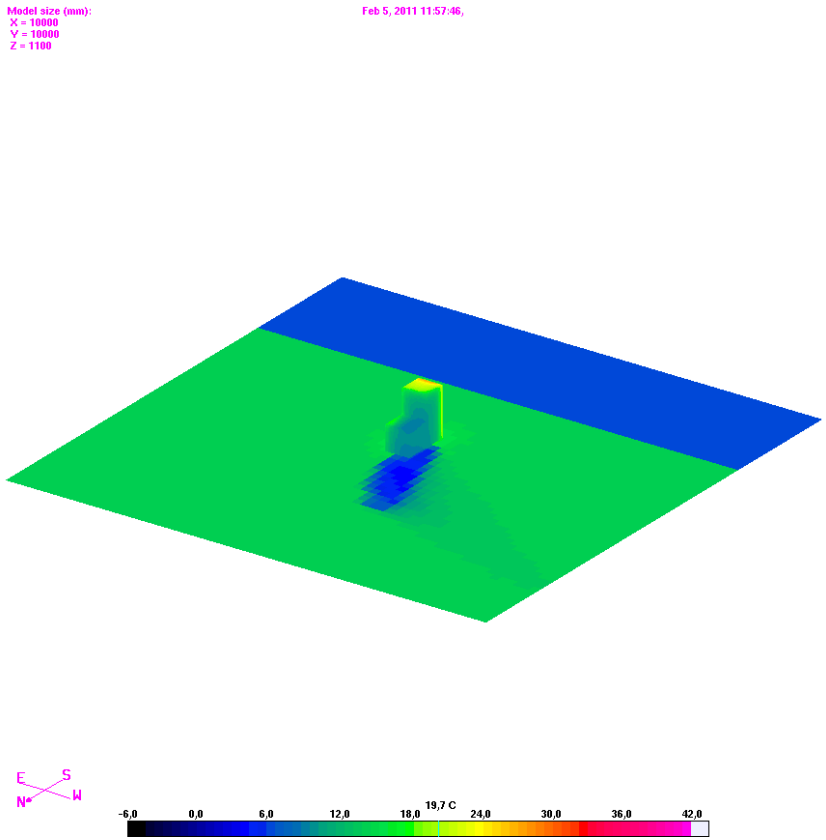
Weather station (Kroneis)

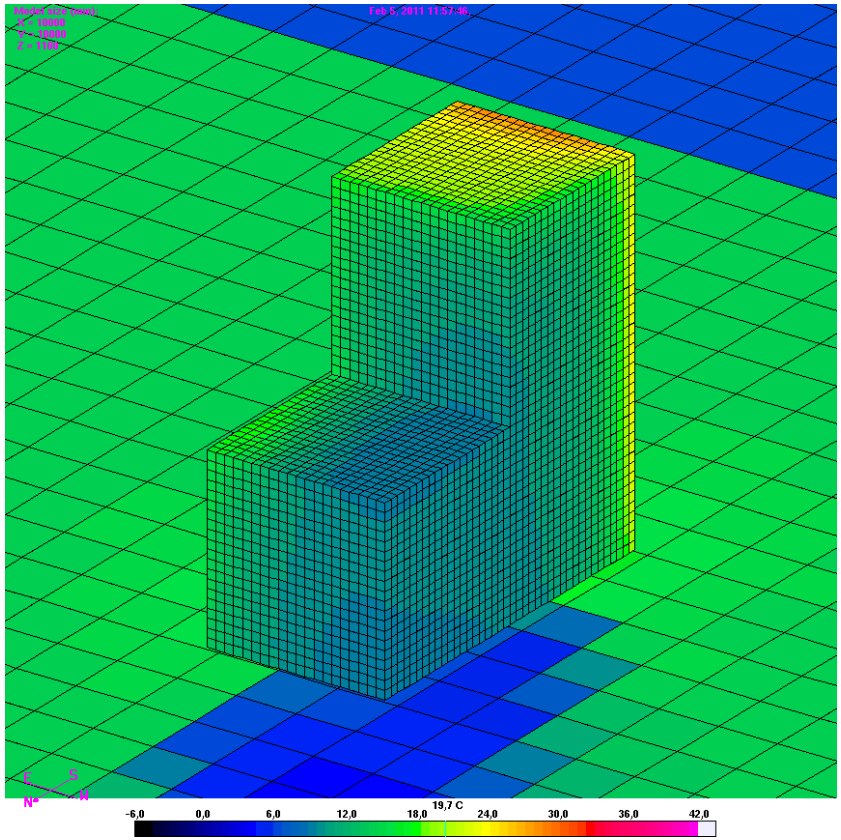
- Pluviometer
- Anemometer with vane
- Barometer
- Hygrometer/Thermometer
- Star pyranometer (solar irradiance, 0.3 – 3 µm)
- Pyrgeometer (downwards LWIR, 4.5 – 44 µm)
- Data logger

RadThermIR model

- RadTherm version 10.0.0
- 14 multi-layer plates (20 x 20 facets each)
- layers: 4 mm steel (mild) + 60 mm rockwool
- natural weather environment, data from weather station
- piece of ground: 10 m x 10 m, resolution 60 x 60 patches
- distance from ground to CUBI base: 10 cm, pallet is not modelled
- convection type
  - outside: ”Wind”
  - inside: ”H and T fluid”, H = 5 W/(m²·K), fluid node for interior air

RadThermIR model





Weather file format (XWA)

- date and time
- wind speed, wind direction
- air temperature
- relative humidity
- barometric pressure
- direct solar beam irradiance
- total solar irradiance
- diffuse solar irradiance
- broadband effective sky temperature
- sensor band effective sky temperature
- cloud cover
- rain rate, rain temperature
- solar zenith and azimuth angle

Weather file format (XWA) – used data

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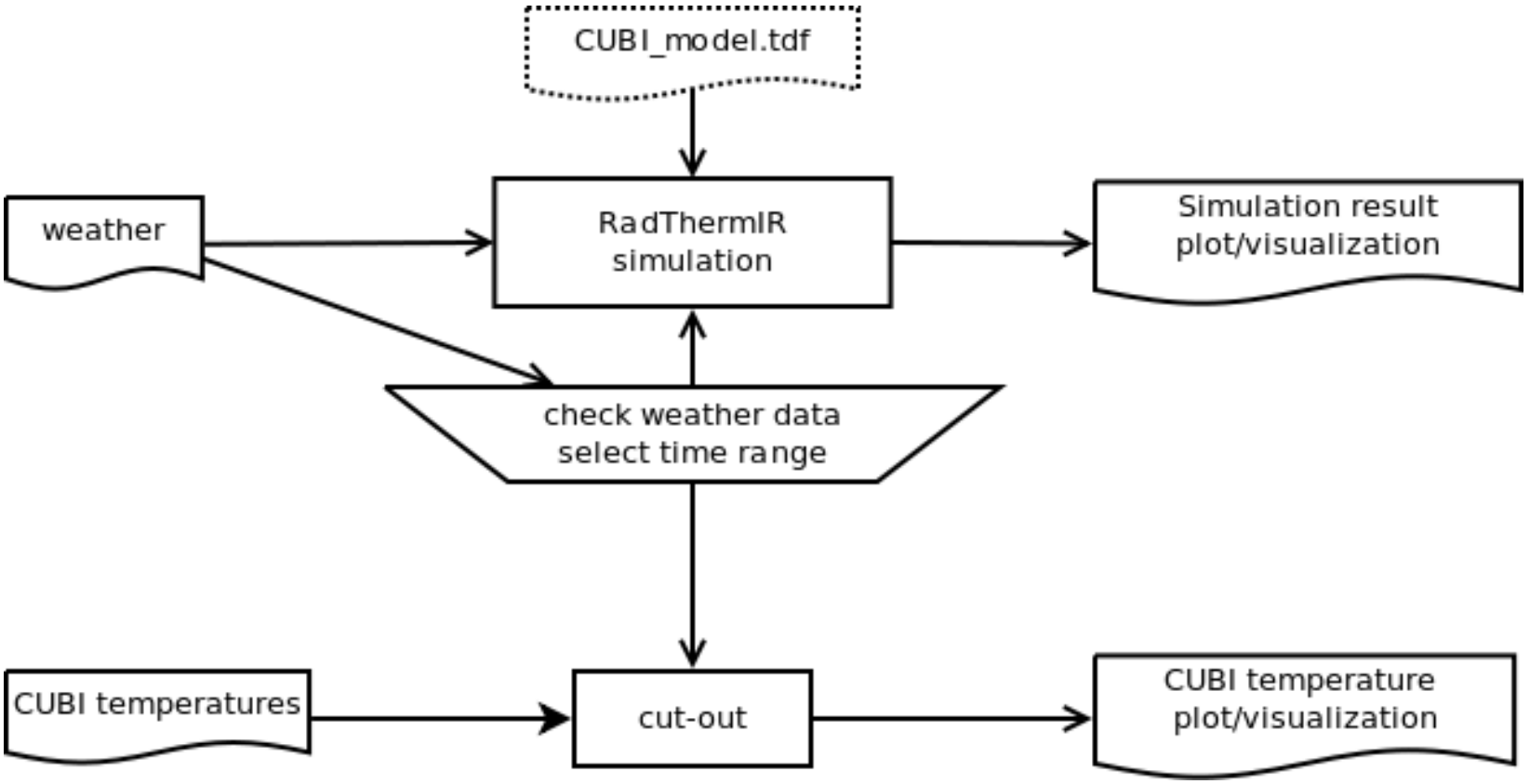
Workflow

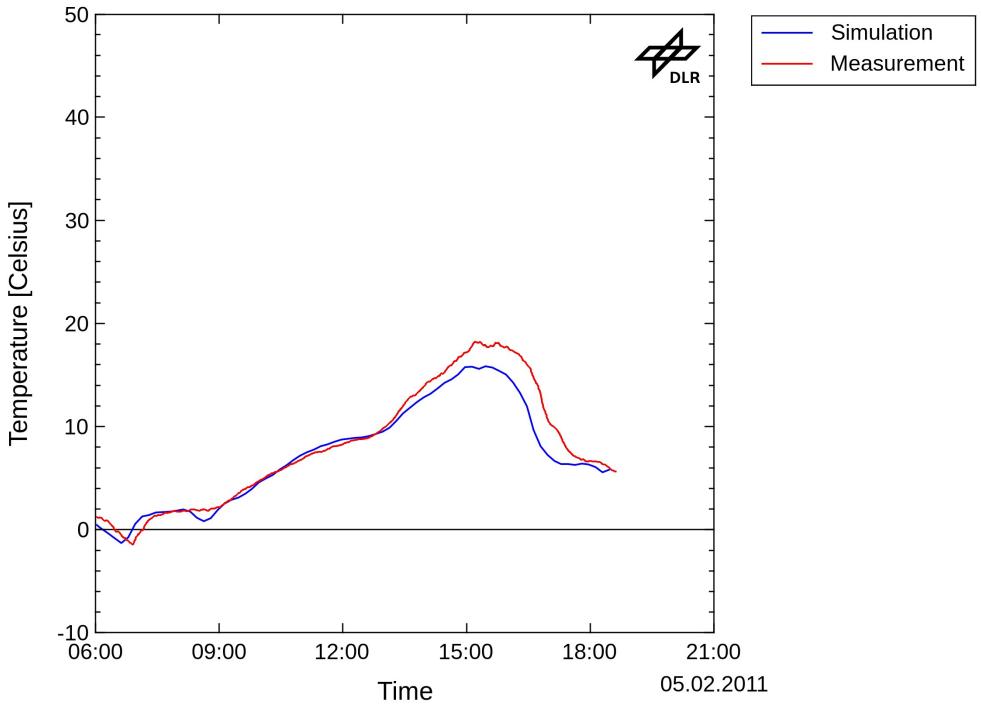

CUBI_model.tdf
weather
RadThermIR simulation
Simulation result plot/visualization
check weather data select time range
CUBI temperatures
cut-out
CUBI temperature plot/visualization

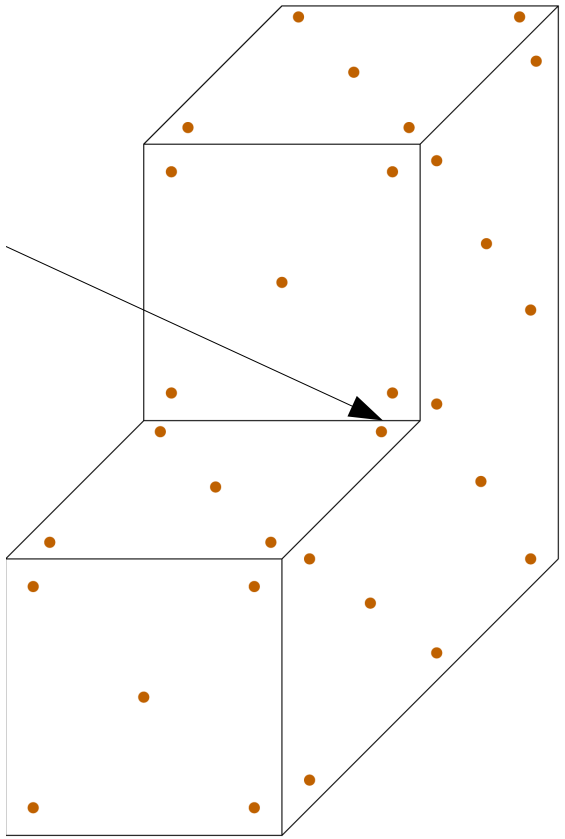
Weather case 1: sunshine

- Feb 5, 2011, 08:17 – 18:37
- no rain
- rel. humidity 32%-75%
- air temperature 3 – 12 °C
- wind speed 1 – 6 m/s

Weather case 1: sunshine

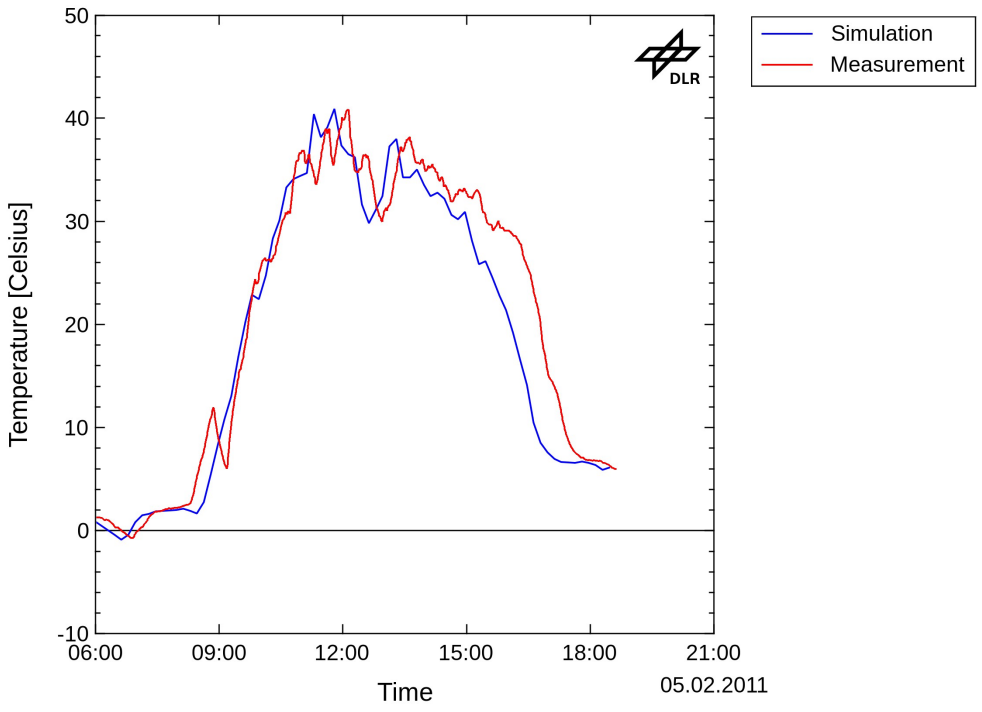
- Shadow on step:

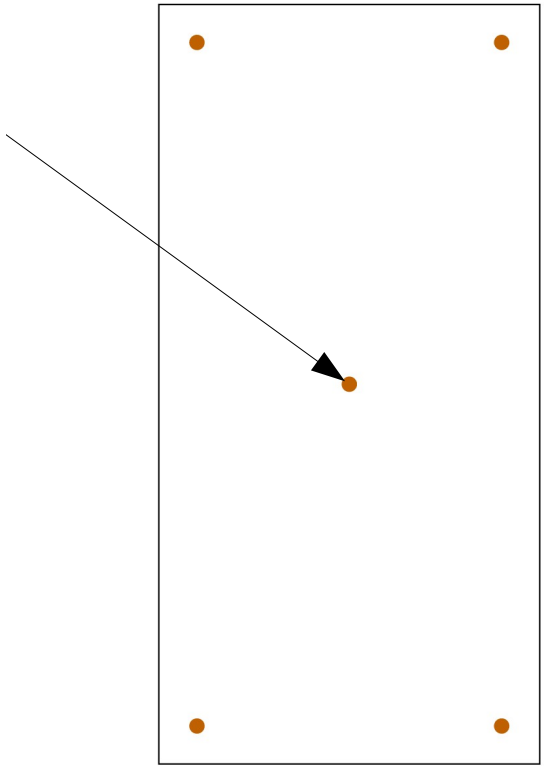




Weather case 1: sunshine

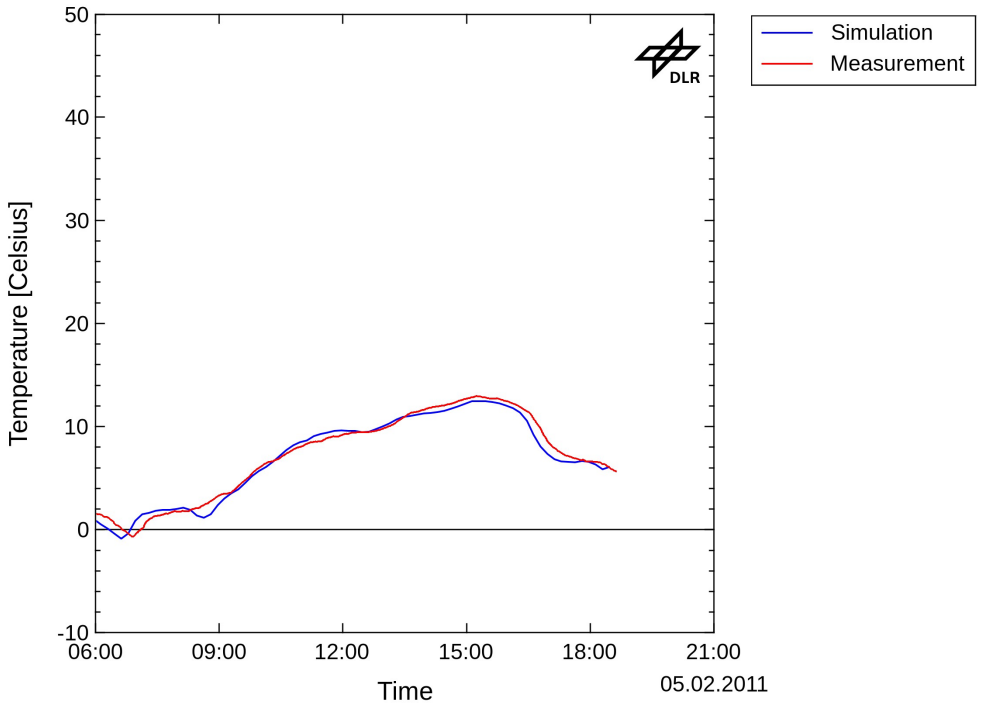
- south face:

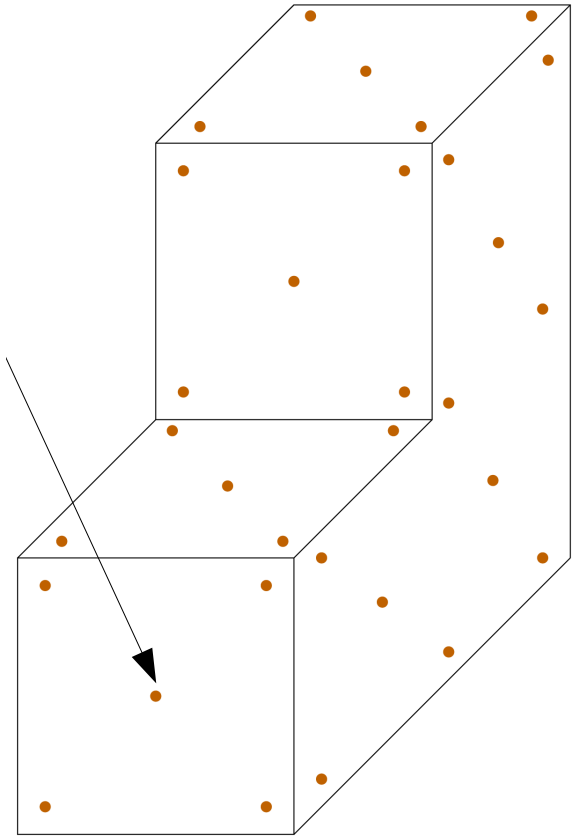




Weather case 1: sunshine

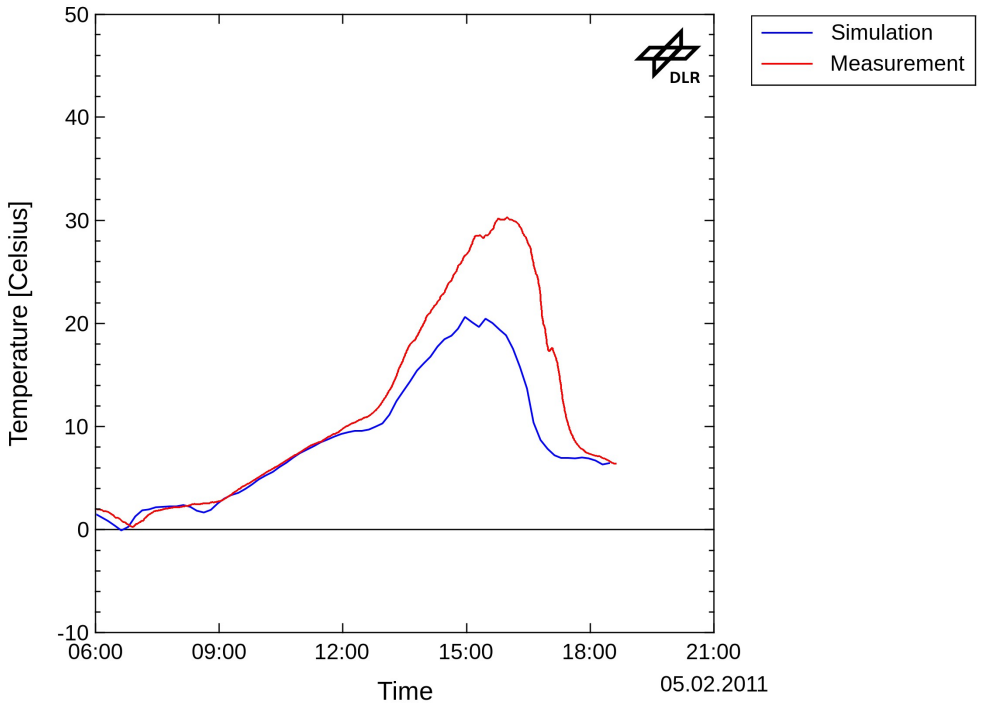
- north face:

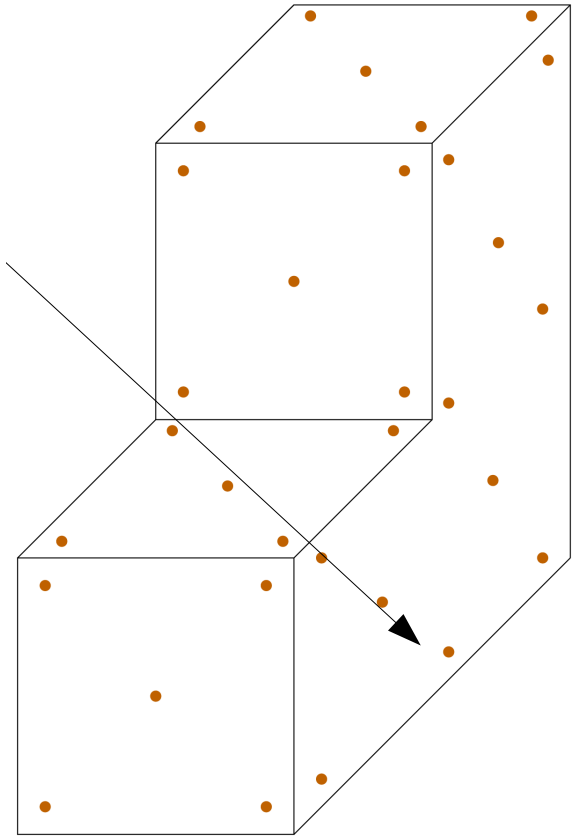




Weather case 1: sunshine

- close to ground:



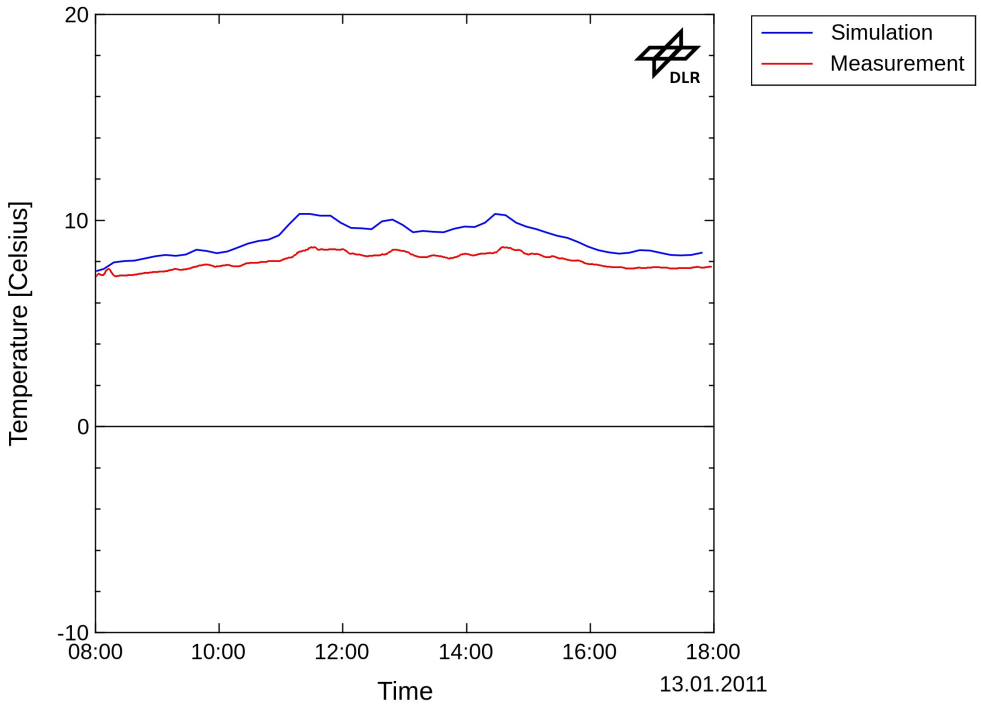


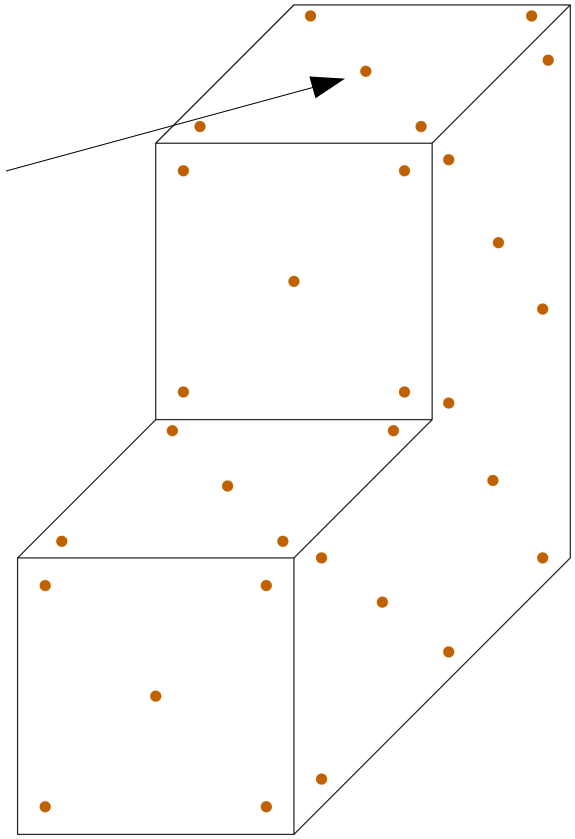
Weather case 2: rainfall and wind

- Jan 14, 2011, 08:47 – 17:57
- rain rate ~1 mm/h
- rel. humidity 83 – 87%
- air temperature 8 – 9 °C
- wind speed 5 – 10 m/s

Weather case 2: rainfall and wind

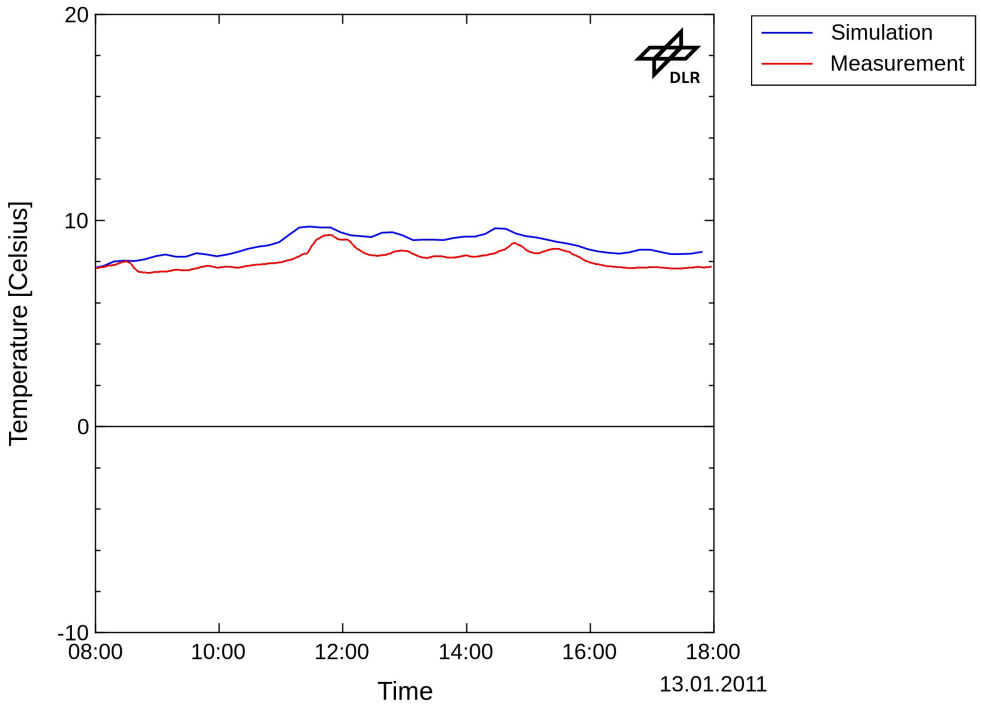
- upper face:

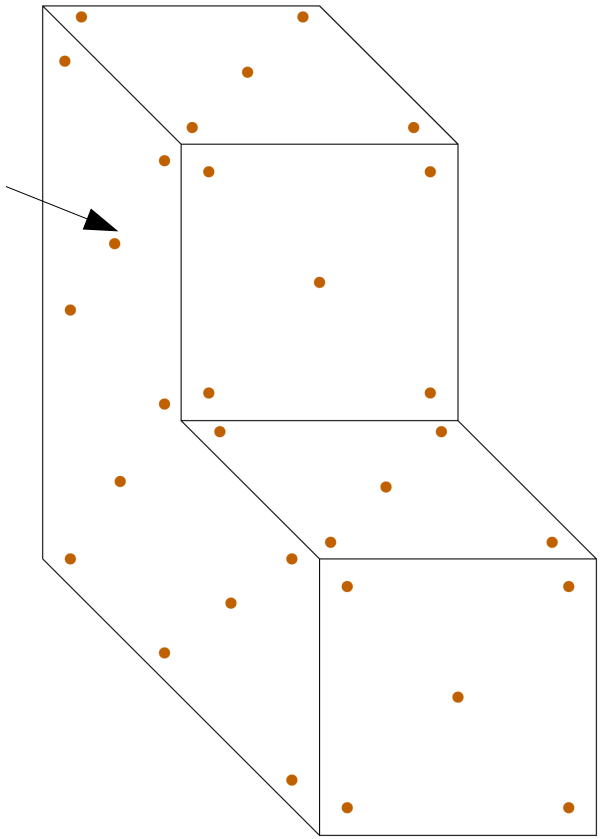




Weather case 2: rainfall and wind

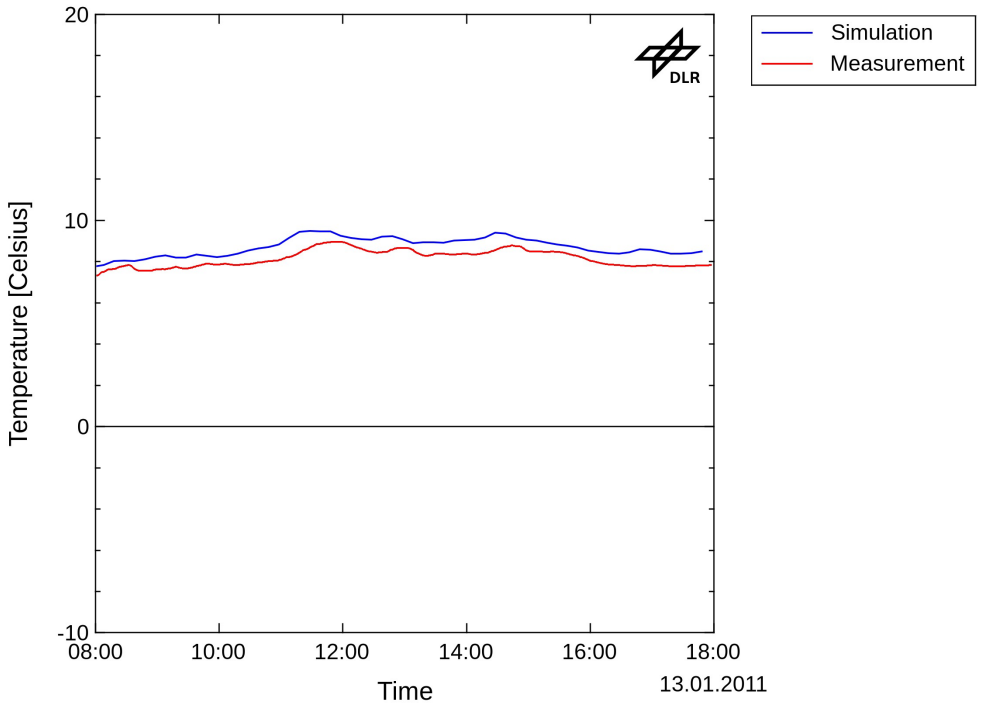
- side face:

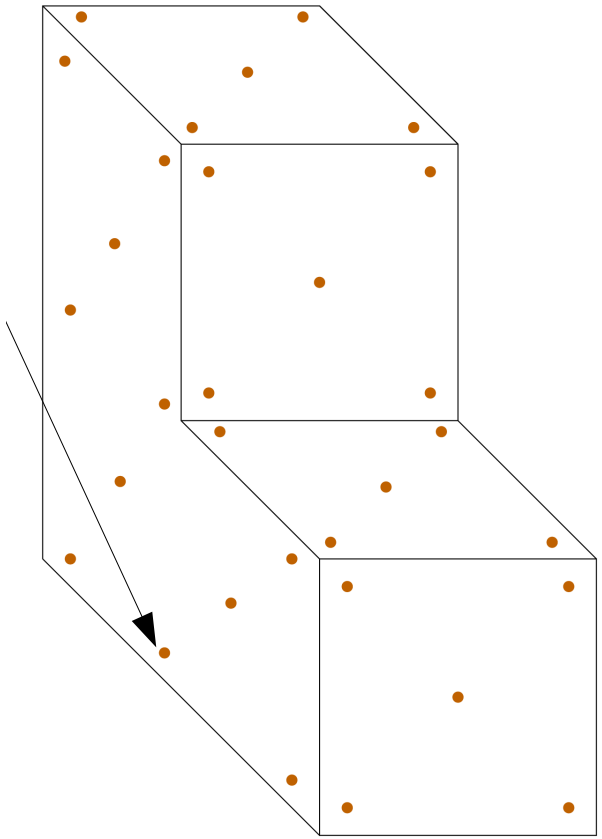




Weather case 2: rainfall and wind

- close to ground:



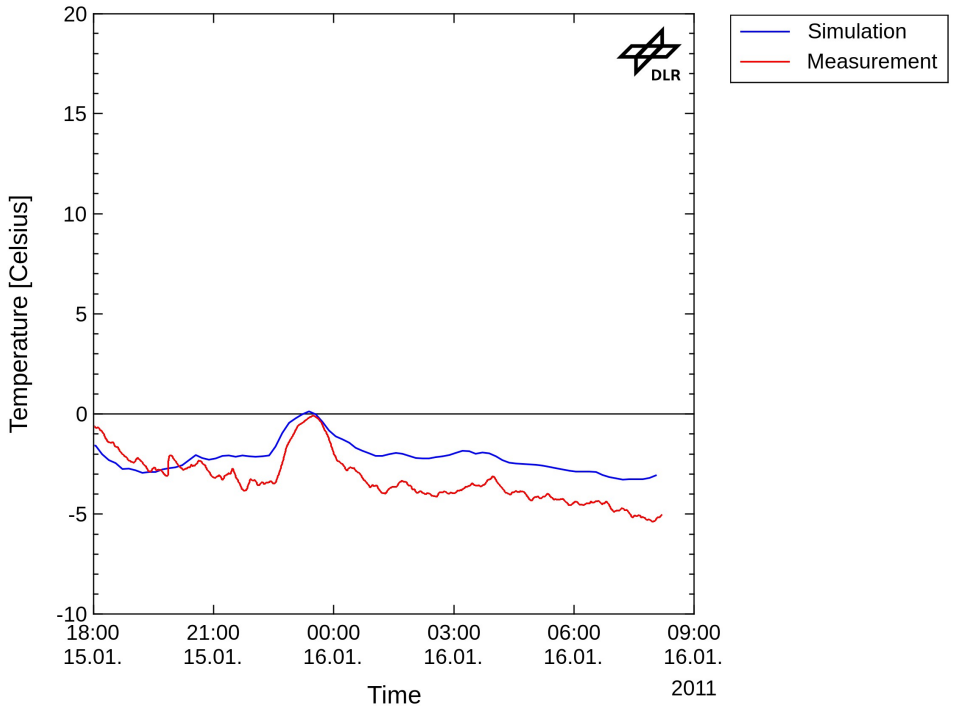


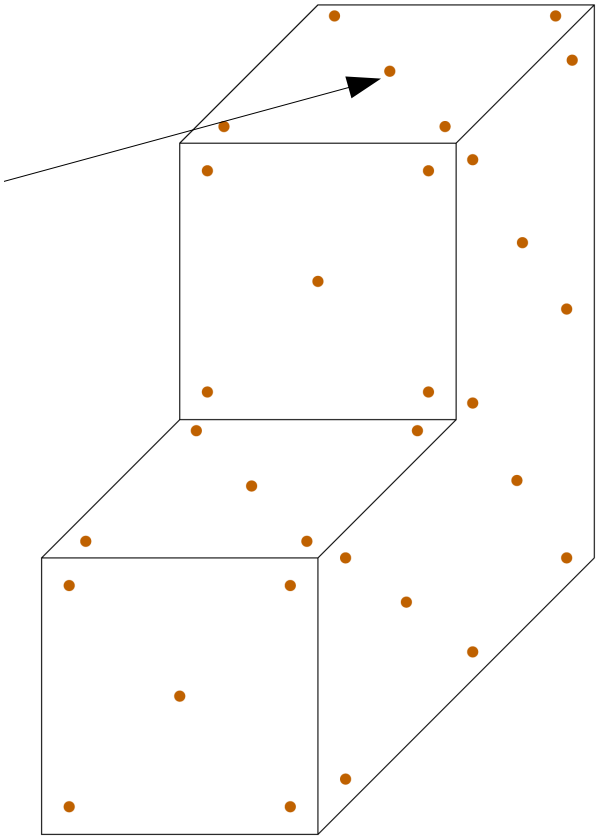
Weather case 3: night

- Jan 15, 2011, 18:12 – Jan 16, 08:42
- no rain
- rel. humidity 85 – 97%
- air temperature -2 – 3 °C
- wind speed 0 – 1 m/s

Weather case 3: night

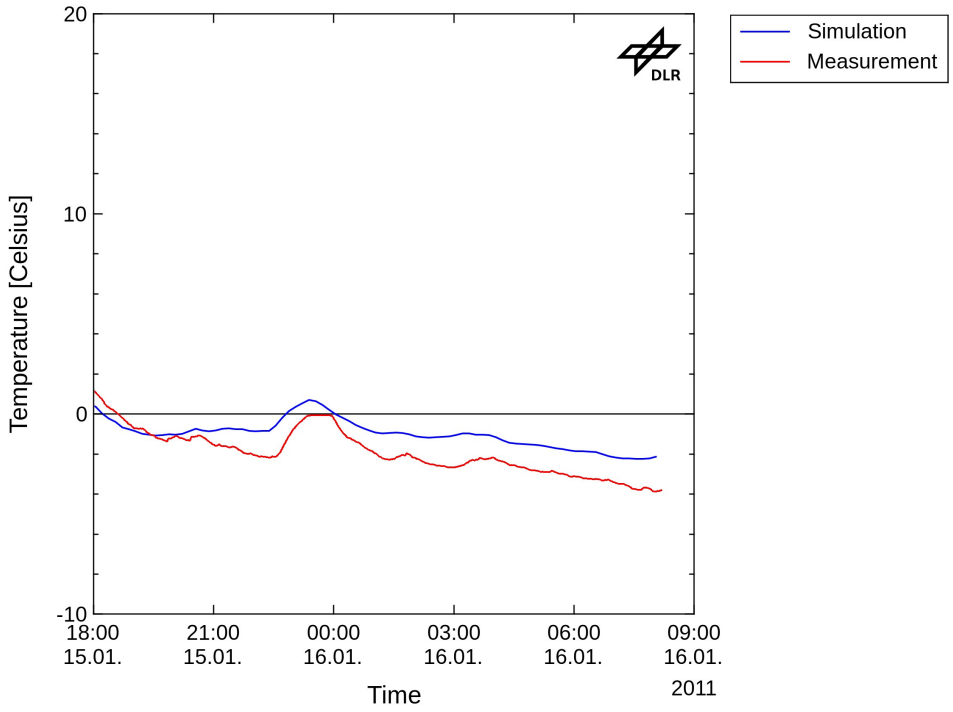
- upper face:

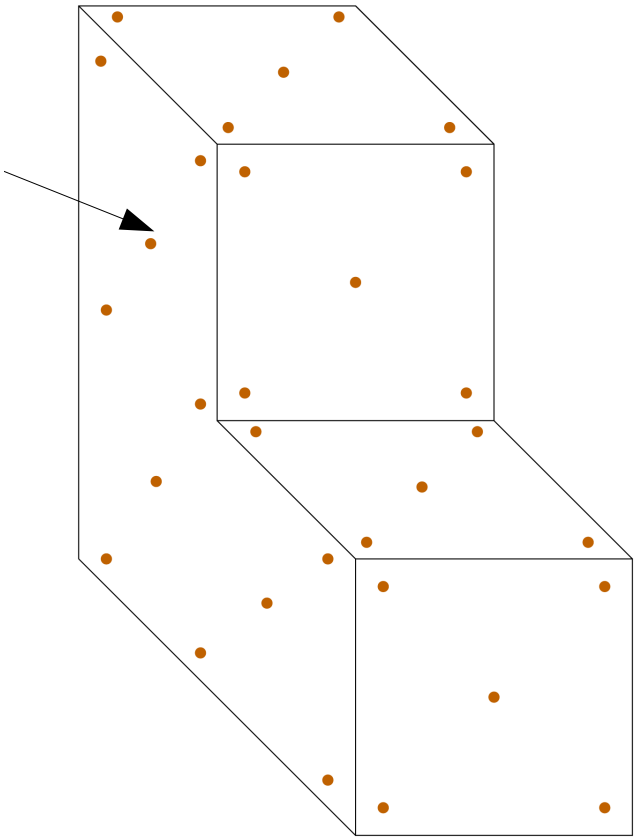




Weather case 3: night

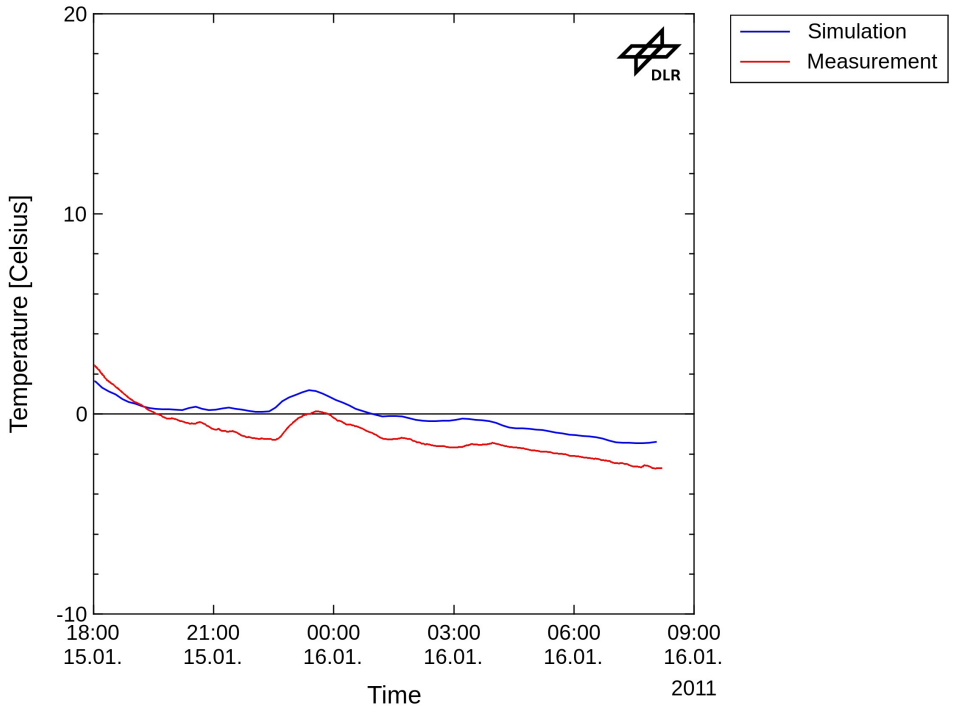
- side face:

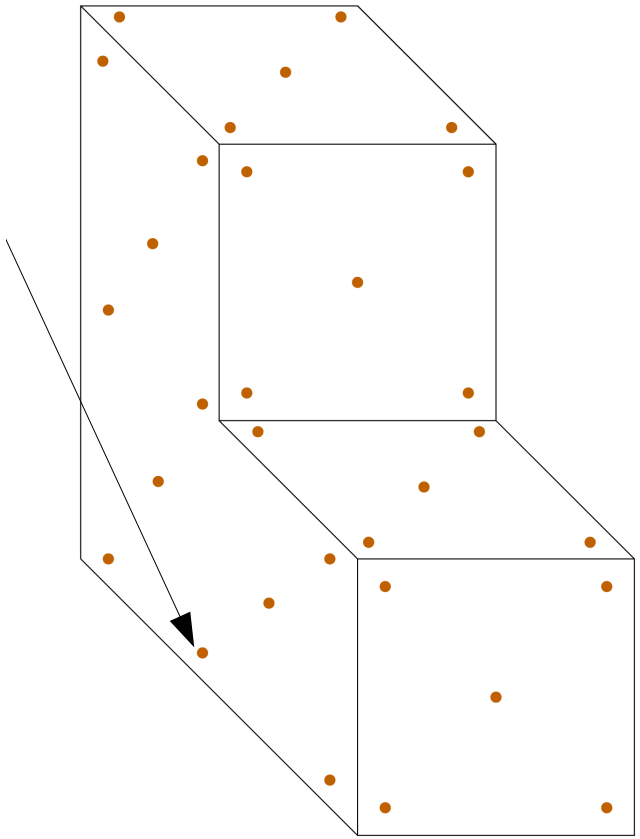




Weather case 3: night

- close to ground:





Summary and Conclusion

- Comparison workflow of measurement and RadThermIR simulation exists
- Different weather conditions have been checked
- Simulation of RadThermIR model agrees well with measurements:
  - in most cases, the difference is < 3 K
  - greater deviations under direct solar irradiation

Outlook:

- Continuous optimization of the model, identification of disturbances
- Installation of IR-Camera planned
- Visualization of data by Visualization Toolkit (vtk)

Thanks to
E. Lindermeir, T. Schwarzmaier, H. Stöhr